NATIONAL UNIVERSITY OF SINGAPORE

CS1010 – PROGRAMMING METHODOLOGY

(AY2017/18 Semester 1)

Time Allowed: 2 Hours

INSTRUCTIONS TO STUDENTS

1. This assessment paper consists of **TWELVE (12)** questions and comprises **NINE (9)** printed pages.

2. This is an **OPEN BOOK** assessment.

3. Calculators and electronic dictionaries are not allowed.

4. Answer all questions, and write your answers in the **ANSWER SHEETS** provided.

5. Fill in your Student Number with a <u>pen</u>, <u>clearly</u> on the first page of your ANSWER SHEETS.

6. <u>Do NOT write your name</u> on your ANSWER SHEETS.

7. You may use **2B pencil** to write your programs.

8. Note that there will be penalty for programs that are unclear or unnecessarily long.

9. You must submit only the ANSWER SHEETS and no other document.

Questions 1 to 6: Each multiple-choice question has only one correct answer. Write your answers in the boxes provided on the **Answer Sheet**. Three marks are awarded for each correct answer and no penalty for wrong answer. [18 marks]

Q1. What is the primary use of flowcharts and pseudocode?

    A. Abstraction

    B. Decomposition

    C. Pattern recognition

    D. Algorithm design

Q2. Assuming that SIZE is a constant defined to be 5, what are the values in array *arr* after the execution of the following code?

```
int arr[SIZE] = { 2, 1, 4, 0, 3 };
int i, j;

for (i=0; i<SIZE; i++) {
   for (j=i+1; j<SIZE; j++) {
      arr[(i+j)%SIZE] += (arr[i] + arr[j])%SIZE;
   }
}
```

    A. { 0, 3, 1, 4, 2 }

    B. { 6, 7, 5, 7, 3 }

    C. { 5, 7, 9, 6, 3 }

    D. { 0, 2, 4, 1, 3 }

    E. None of the above.

Q3. What is the output of the following code fragment?

```
int a=5, b=1, c=3;

a += --b || c++ * b;
printf("a = %d; b = %d; c = %d\n", a, b, c);
```

    A. a = 5; b = 0; c = 4

    B. a = 8; b = 0; c = 4

    C. a = 9; b = 0; c = 4

    D. a = 6; b = 1; c = 3

    E. None of the above.

Q4. What is the output of the following code fragment?

```
char *str1 = "Hello", *str2 = "Hello";
if (str1 == str2)
    printf("equal; ");
else
    printf("not equal; ");

if (strcmp(str1, str2))
    printf("equal\n");
else
    printf("not equal\n");
```

A. `not equal; not equal`

B. `equal; not equal`

C. `not equal; equal`

D. `equal; equal`

E. It will give compile-time error.

Q5. Given the following function:

```
// Precond: n > 0
int f(int n) {
   int a, b, count = 0;

   for (a = 0; a <= n; a++) {
      for (b = a; b <= n; b++) {
         count++;
      }
   }
   return count;
}
```

What does f(n) compute?

A. $n^2/2$

B. $(n-1)^2/2$

C. $n(n-1)/2$

D. $n(n+1)/2$

E. None of the above.

Q6. What is the output of the following program?

```
typedef struct {
    char name[20];
    int age;
} student_t;

void doSomething(student_t);

int main(void) {
    student_t s1 = {"Alice", 20};
    doSomething(s1);
    printf("%s is %d years old.\n", s1.name, s1.age);

    return 0;
}

void doSomething(student_t s){
    s.name[0] = '\0' ;
    s.age = 0;
}
```

A. `is 0 years old.`
B. `is 20 years old.`
C. `Alice is 0 years old.`
D. `Alice is 20 years old.`
E. None of the above.

Questions 7 to 12:

Write your answers in the space provided on the **Answer Sheets**. You may write in pencil. You are to write legibly or marks might be deducted.

Q7. [6 marks]

The following function **f()** is very badly written as it does not follow good programming practice.

```c
void f(int arr[], int n) {
   float average, min_average;
   int i;

   min_average = (arr[0] + arr[1] + arr[2])/3.0;
   for (i=2; i<n-1; i++) {
      if ((arr[i-1] >= arr[i]) || (arr[i] >= arr[i+1])) {
         continue;
      }
      else {
         average = 0.0;
         average += arr[i-1];
         average += arr[i];
         average += arr[i+1];
         average /= 3.0;
         if (average >= min_average) {
            continue;
         }
         else {
            if (average < min_average) {
               min_average = average;
            }
            else { // do nothing
            }
         }
      }
   }
   printf("The answer is = %f\n", min_average);
}
```

(a) The pre-condition is missing. Fill in the pre-condition for this function.   [1 mark]

(b) Rewrite the function to compute the same result, following good programming practice. Do not rename any of the variable names or parameter names, and do not introduce new variables. You may change the return type of the function.   [5 marks]

Q8. **[6 marks]**

Write the output of the following program.

```c
#include <stdio.h>
int main(void) {
    int a = 3, *b, c, *d, e, *f;

    b = &a;
    *b = 5;
    c = *b * 3;
    d = b;
    e = *b + c;
    *d = c + e;
    f = &e;
    a = *f + *b;
    *f = *d - *b;

    printf("a = %d, c = %d, e = %d\n", a, c, e);
    printf("*b = %d, *d = %d, *f = %d\n", *b, *d, *f);

    return 0;
}
```

Q9. **[5 marks]**

A *geometric progression* is a sequence of numbers where each term after the first is found by multiplying the previous one by a fixed, non-zero number called the *common ratio*. For example, the sequence 2, 6, 18, 54, ... is a geometric progression with common ratio 3. Write a function called **IsGP()** that takes in 3 integers, and returns 1 if the three integers can form 3 consecutive numbers in a geometric progression, or 0 otherwise.

Take note of the following requirements:

- The 3 arguments need not be in the correct order of the sequence. For example, IsGP(2,6,18), IsGP(18,2,6) and IsGP(2,18,6) will all return 1, while IsGP(2,18,5) will return 0.

- You are not allowed to sort the sequence.

- To receive full credit, your function should contain only a single statement.

Q10. **[7 marks]**

Imagine that there are 100 cities. An airline has a direct flight between any two cities, and each flight comes with a cost. The cost of flying between two cities in one direction may be different from the cost of flying in the opposite direction. You are interested in finding the lowest cost of travel from a city to another city, and in between you would like to stop over at a third city. For simplicity, cities are named by numbers from 0 to 99.

(a) How would you represent the flight cost data? [1 mark]

(b) Using your data model, given two cities *A* and *B*, how would you find the lowest cost of travel from *A* to *B*, with a stopover at another (any) city *M* in between, where *A*, *M* and *B* are distinct cities? You are also to identify the city *M*. You may write your answer in pseudocode, although C code is also acceptable. [6 marks]

Q11. **Structure and file [26 marks]**

You are the owner of a bookshop specializing in Computing and Cookery books. To keep track of your books, you decide to write a book catalogue system. The information you intend to keep on each book is:

Book title: The title of each book, limited to 45 characters.
Author: The author of the book, limited to 45 characters.
ISBN: This is a serial number in the form XXX-X-XX-XXXXXX-X.
(For example, the ISBN of the 7th edition of the Hanly/Koffman textbook is 978-0-13-293649-1)
Price: This is expressed in dollars, e.g. 69.95 means that the book costs $69.95
Quantity: The number of copies you have in stock.

You define the following structure to store information for each book.

```
#define MAX_STRING_LEN 46
#define ISBN_LEN 18

typedef struct{
  char title[MAX_STRING_LEN];
  char author[MAX_STRING_LEN];
  char isbn[ISBN_LEN];
  float price;
  int qty;
} book_t;
```

(a) Define a suitable array of structures that will store information on all your books. You may assume that you will not stock more than 800 titles.   [4 marks]

(b) Write a function **read_file()** that reads book information from a specified file. A sample of the file's contents is shown below:

```
Problem Solving and Program Design in C
Jeri Hanly, Elliot Koffman
978-0-13-293649-1
69.95
17
Jamie Oliver's Meals in Minutes
Jamie Oliver
978-1-40-132442-1
29.90
23
Mary Berry Cooks
Mary Berry
978-1-84-990663-0
40.25
17
The Z Notation
J. M. Spivey
978-0-13-978529-0
25.55
20
...
```

The first line is the title, followed by the author name, ISBN, price and quantity, each on a new line. Each book's information therefore takes up five lines. Information of subsequent books follow immediately. The function declaration is given here:

```
int read_file(char filename[], book_t book_list[])
```

The first argument is the filename, the second is the array of books. This function returns the number of records read.   [12 marks]

(c) Write a function **print_books()** to print the book data in the array. The output should look something like this:

```
Problem Solving and Program Design in C, by Jeri Hanly,
Elliot Koffman, ISBN 978-0-13-293649-1, SGD69.95, Qty 17.

Jamie Oliver's Meals in Minutes, by Jamie Oliver, ISBN
978-1-40-132442-1, SGD29.90, Qty 23.

Mary Berry Cooks, by Mary Berry, ISBN 978-1-84-990663-0,
SGD40.25, Qty 17.

. . .
```

The function header is given below:

void print_books(book_t book_list[], int size) [5 marks]

(d) Write the **main()** function that uses the above functions to:
   i. Read from a file called "books.dat"
   ii. Print the book data. [5 marks]

Q12. Matrices and recursion [12 marks]

Write a recursive function **borderMatrix()** that will take in an n x n array ($1 < n \leq 10$) and produce alternating borders of 1 starting from the outermost layer. <u>No marks will be given if recursion is not used</u>.

You may assume that the matrix has been pre-initialised to 0. The function header is given below:

void borderMatrix(int mtx[ ][MAX_COL], int start, int stop)

The following shows the first invocation of the function:

borderMatrix(mtx, 0, n − 1);

See example arrays:

$n = 2$	$n = 3$	$n = 6$	$n = 7$
1 1	1 1 1	1 1 1 1 1 1	1 1 1 1 1 1 1
1 1	1 0 1	1 0 0 0 0 1	1 0 0 0 0 0 1
	1 1 1	1 0 1 1 0 1	1 0 1 1 1 0 1
		1 0 1 1 0 1	1 0 1 0 1 0 1
		1 0 0 0 0 1	1 0 1 1 1 0 1
		1 1 1 1 1 1	1 0 0 0 0 0 1
			1 1 1 1 1 1 1

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